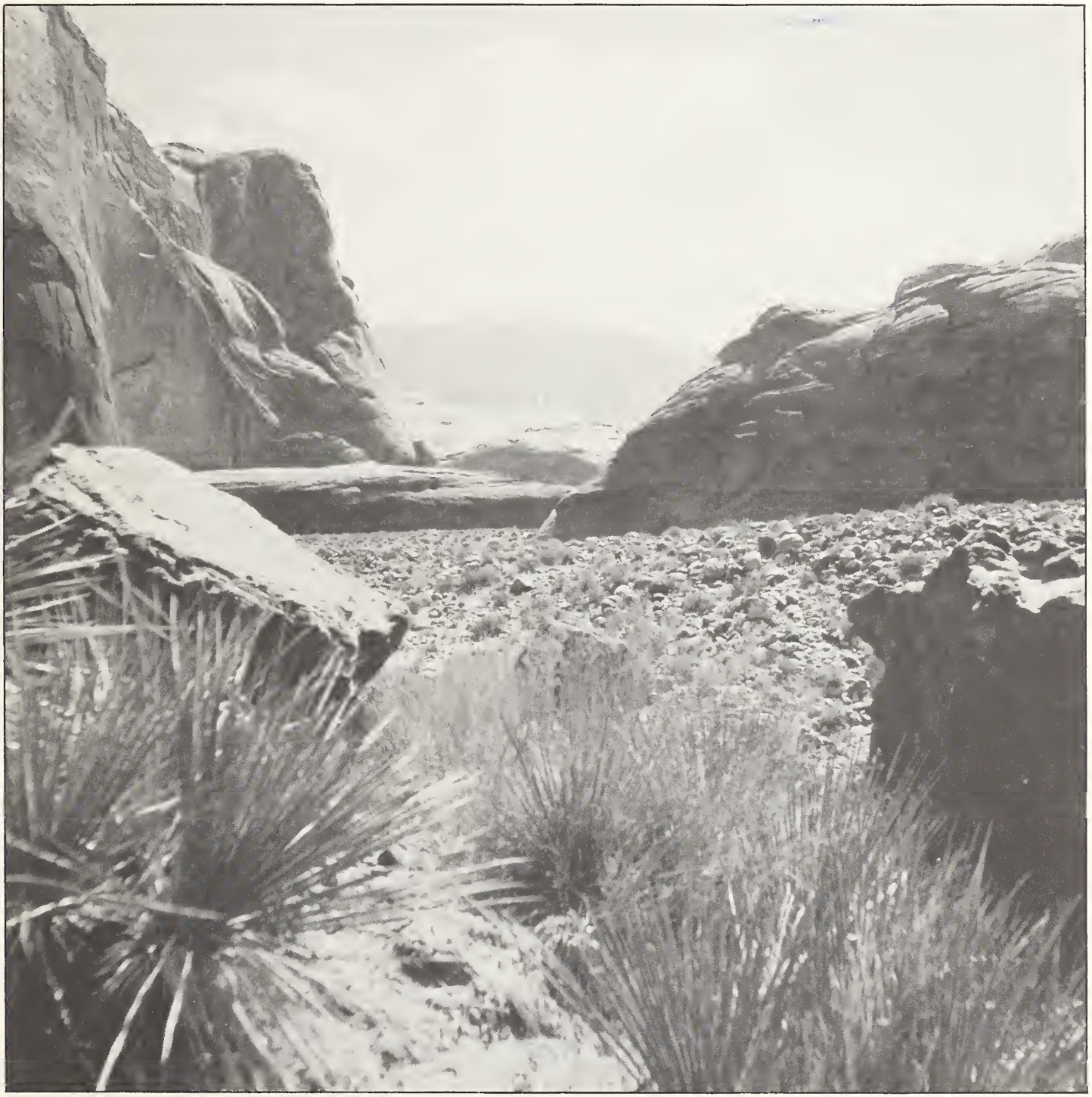
United States Department of Agriculture

Forest Service

December 1983

Forestry Research West



A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

Forestry Research West

In This Issue

Cover

Scientists with the Rocky Mountain Station have helped develop a system to enable resource specialists to put into practice a concept for inventorying, classifying, managing, and monitoring outdoor recreation resources. The system incorporates six broad classes of recreational opportunities. This, the primitive class, is characterized by an unmodified natural environment. Read more about it on page 6.

To Order Publications

Single copies of publications referred to in this magazine are available without charge from the issuing station unless another source is indicated. See page 19 for ordering cards.

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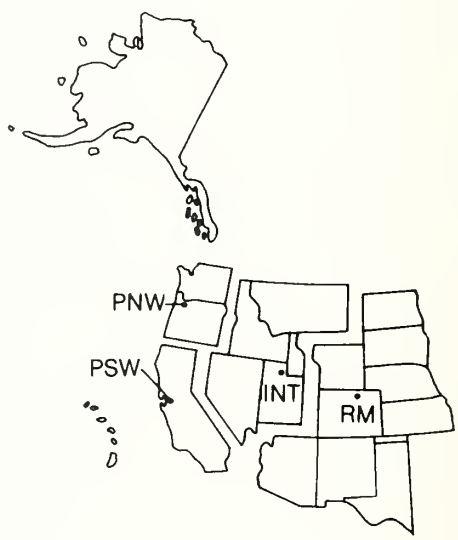


Where man is a visitor

by Delpha Noble
Intermountain Station

Wilderness campsites are most severely altered by recreational use.

Where wilderness was once a challenge to be overcome, today the challenge is to protect the quality of what Congress defined as "an area untrammeled by man, where man himself is a visitor who does not remain."

Today some 80 million acres are protected under the Wilderness Act of 1964; millions more are being proposed for wilderness status. Within the National Forests, wilderness status has been recommended for over 600 areas totaling about 15 million acres.

As more areas are included in the National Wilderness Preservation System (NWPS), management of recreational use will play an increasingly important role. Limitations on development and the emphasis on relatively natural conditions, coupled with ever-increasing numbers of visitors, require use management.

Developing methods to meet this challenge governs the research efforts of the Intermountain Station's Wilderness Management research unit at the Forestry Sciences Laboratory, Missoula, Montana. Missoula, located in the center of the northern Rocky Mountains, is an ideal place for wilderness research.

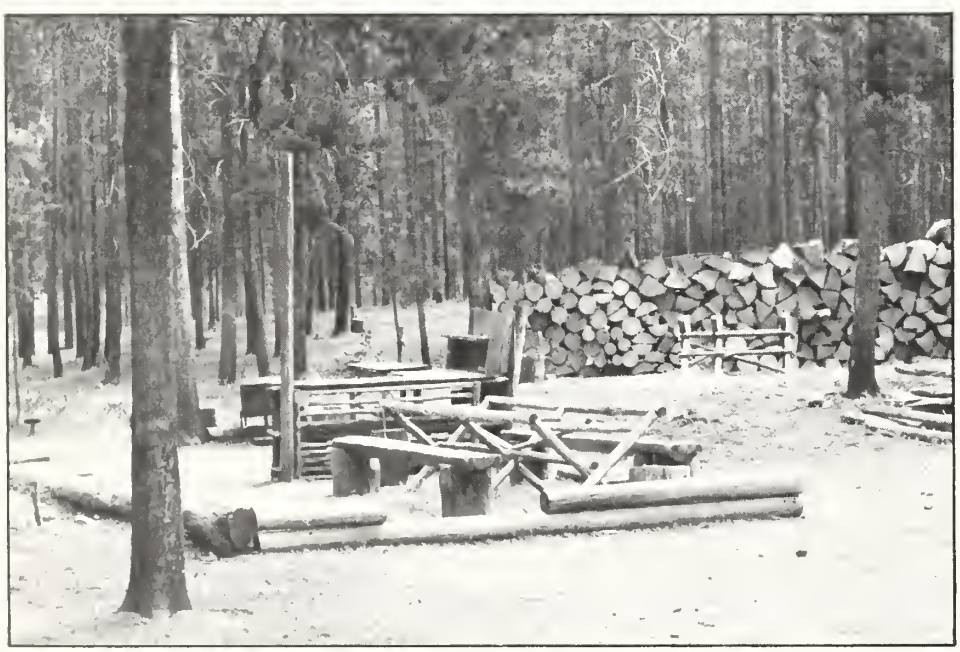
This area contains the largest concentration of wilderness in the contiguous 48 States: Idaho, Montana, and Wyoming have over 25 Wilderness or Primitive Areas in National Forests, three major National Parks with wilderness lands, and a substantial area of undeveloped roadless land. The River of No Return Wilderness in Idaho includes almost 2¼ million acres. The Selway-Bitterroot sprawls across more than a million acres of Idaho and Montana. The Bob Marshall, within the Flathead and Lewis and Clark National Forests, brackets 60 north-south miles of the Continental Divide in western Montana.

Dr. Robert C. Lucas, project leader, and other researchers with the wilderness unit are working to provide an information base for the management of wilderness. Their studies run the gamut from studying visitor attitudes, knowledge, and activities, to determining the impact of visitors on plants, soil, water, and wildlife.

Other wilderness values, particularly scientific, historical, cultural, and ecological, are important. Dr. Lucas says, "A wilderness is not intended to serve primarily as a recreation area." In fact, a few Wildlife Refuge wildernesses are closed to recreational visitors, but these other values generally pose less critical management problems than does the growing recreational use.

Numbers of visitors have mushroomed since the late 1940's, increasing about 15 times. Where the visitor once roamed a wilderness at will, tenting where fancy chose, today he might meet a ranger who would instruct him thus: "Mirror Lake is closed to camping and grazing. In the Skyhigh Basin wood fires are prohibited. You can stay only one night at Little Salmon Creek and Gordon Creek. Oh, and please remember to camp at least 100 feet away from lakes and streams. Thank you and have a good trip." Such a thicket of restrictions is perceived as necessary in many areas to protect vegetation from trampling, streams from pollution, and solitude from crowds.

Semipermanent tent frames, woodpile, and kitchen facilities typical of outfitters' camp.



But the wilderness management researchers ask, "Is something wrong here?" Recreation and visitor regulations are inherently contradictory. Recreation is a voluntary, pleasurable, rewarding activity, based on free choice, while regulations are designed to restrict free choices. In many cases, the regulatory, direct management approach can lead to strains between visitors and managers. An alternative is indirect management, basically "soft sell." With this approach, managers seek to shift use patterns and alter visitor behavior, but in a way that is not offensive to visitors.

Lucas says wilderness regulations sometimes are adopted without enough analysis of necessity or of alternatives. Area managers are conscientious and concerned and they want to do something rather than stand by passively. He believes that a systematic analysis should precede the adoption of recreation management actions, particularly regulations. He says, "Close calls should go to nonregulatory approaches.

To help managers determine whether regulations are necessary, the researchers have developed a seven-step system that should result in fewer, but better, regulations:

1. identify the problem,
2. determine causes,
3. identify and evaluate potential nonregulatory approaches,
4. accept or reject the approaches,
5. identify and evaluate regulatory approaches,
6. accept or reject, and conduct further analysis, and
7. implement and monitor effectiveness and costs.

Managing visitors through information

Providing wilderness visitors with information that can influence where they go, what they do, and how they do it is a particularly promising indirect management method. It is non-authoritarian and permits the manager to be a helpful guide rather than someone who restricts and regulates. As a result, conflict and controversy can be avoided.

How effective is information as a tool for use redistribution? Dr. Lucas sought answers to that question in a study conducted in the Selway-Bitterroot. Concerned about highly concentrated use, the Stevensville Ranger District staff distributed a brochure providing information on levels of use at each trailhead, expressed as a percent of the total. The brochure also explained how to find each trailhead and identified heavily-used campsites. At the request of management, the wilderness management researchers evaluated this effort.

The results of this evaluation, together with other similar studies, indicate that the effect of information on wilderness use distribution can range from none to substantial. But Lucas cautions that if information is to be a useful management tool, it must be used in particular ways: information campaigns must be geared to management objectives; the information must be delivered to a large proportion of visitors; and it must be delivered early enough in the recreation location choice process to be useful.

Campsites

One of the wilderness manager's most vexing problems is deciding what to do about degradation of campsites in areas where use is concentrated. To solve this problem, or to develop any other sound campsite management policy, managers need information about changes that are taking place. They also need to know the extent to which differences in amounts of use affect campsite conditions.

In recent years, managers also have been under pressure to improve the professionalism and accountability of wilderness management. The National Forest Management Act of 1978 includes the requirement that Forest Service Wilderness Managers monitor the response of the wilderness resource to management of visitor use.

Dr. David N. Cole, research ecologist with Systems for Environmental Management, Missoula, and cooperator with the wilderness unit, has conducted several studies of wilderness campsites to help develop monitoring techniques to meet the need for baseline information. According to Dr. Cole, the most useful monitoring systems should be designed to evaluate a number of meaningful specific variables, record each of them separately, use precise, affordable techniques, and be able to inventory all sites.

"That's a tall order," says Dr. Cole, "thus estimation techniques will probably have to be used in most areas where funds are short and campsites are numerous." During his work with the wilderness unit, Dr. Cole developed specific recommendations for monitoring the condition of wilderness campsites.

In a study in the Eagle Cap Wilderness in northeastern Oregon, Dr. Cole evaluated the success of dispersal of visitors—that is, directing them from overused areas to less frequently visited parts of the wilderness. He also assessed the ability of several individual monitoring methods currently used to predict general site conditions and amount of change.

The Bob Marshall Wilderness was an ideal field laboratory for another study of campsite conditions, also conducted by Dr. Cole. In the western United States, most studies of campsite conditions have been made at high elevations; the conclusions may not apply to campsites at lower elevations. (Much of the Bob Marshall is relatively low for a mountainous wilderness in the West.) In addition, previous studies have not compared the condition of campsites subjected to very different types of use. These informational gaps provided the impetus for long-term monitoring of campsites in the Bob Marshall, an area frequented by backpackers, private individuals with packstock, and commercial outfitters and their clients.

Trails

Monitoring is also important in managing backcountry trails. In a study of the Big Creek trail system in the Selway-Bitterroot Wilderness, Dr. Cole used specific techniques developed to assess conditions and monitor future changes. The results of the study provide an assessment of current conditions and the severity of future deterioration in this trail system, as well as guidelines for trail location and design.

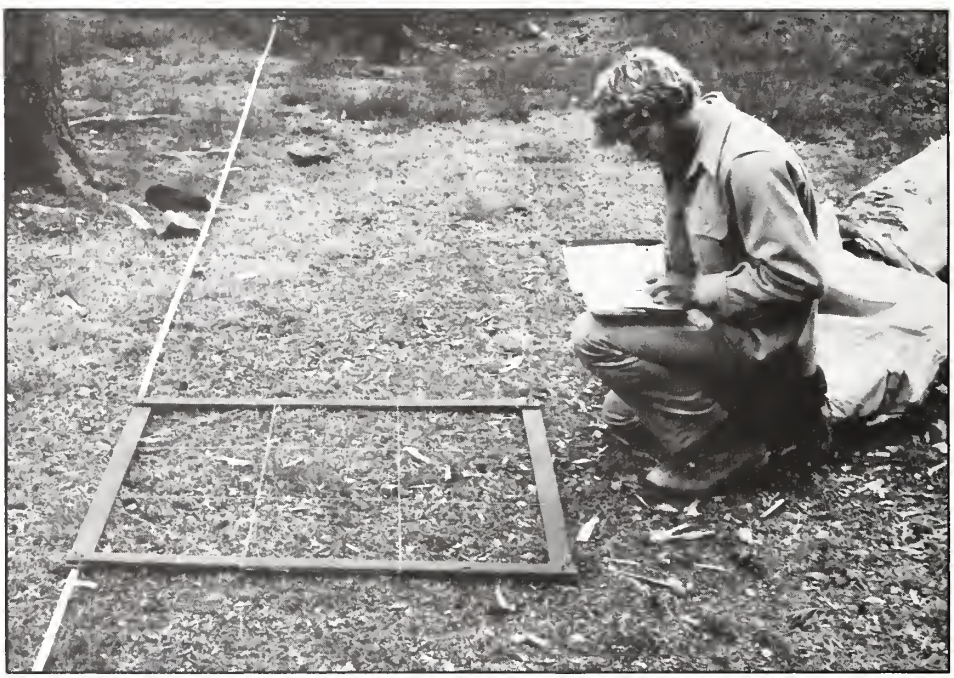
Campfires

The campfire—a small blaze to cheer the night. Most recreationists expect this amenity during their wilderness visits. But the accumulation of ashes and partly burned wood in a rustic fire ring of blackened rocks is an obvious sign of man's activities.

Managers of many backcountry areas have become concerned with the aesthetic impacts of fire sites and the ecological impacts of collecting and burning wood. Responding to this concern, Dr. Cole and John Dalle-Molle, resource management ranger at Denali National Park and Preserve, Alaska, developed management strategies to deal with the impacts of campfires. According to them, there are four basic strategies for managing these impacts: prohibition of fires, concentrating campfires on a few sites, dispersing fires to a large number of sites, and no action. Cole and Dalle-Molle also analyzed the advantages and disadvantages of each strategy in differing situations.

Use estimation

Unmanned, voluntary trail registers are used by managers of many wilderness areas to obtain information about recreational use. Use estimates can be used for budgeting, to set work schedules, to provide visitors with information about use patterns, and, in some cases, to limit use. But it is common knowledge, according to Dr. Lucas, that a significant proportion of visitors do not register. In a study conducted by Dr. Lucas at seven trailheads on the Bob Marshall, only 20 percent of the parties registered. This was documented by automatic traffic counters which triggered movie cameras. The film provided a nearly complete record of the amount and type of use from late June through mid-November 1981. Dr. Lucas says that unless trail register compliance rates are higher than he found in the Bob Marshall and during another study in the Selway-Bitterroot (28 percent), trail registers cannot provide a useful base for estimating recreational use. A current study by Margaret Petersen of the research unit is examining the effect on registration of the message and design of trail registers as well as their location at the trailheads compared to up the trails.



Worker uses a meter-square quadrat to measure vegetation cover on a wilderness campsite.

Wilderness manager survey

Wilderness is a professional responsibility of many resource managers in the Forest Service, National Park Service, Fish and Wildlife Service, and Bureau of Land Management. Wilderness management philosophies, current management capability, and interest vary not only among the four managing agencies, but within them as well.

In a study of these differences, Dr. Cole and Dr. Randel F. Washburne, formerly a social scientist with the wilderness research unit, surveyed managers of all units within the NWPS in 1980 and many units that probably will be added. Results of the survey illustrate the diversity of the system, which includes 269 areas and spans over 6,000 miles. The researchers determined that, in spite of such diversity, most of the NWPS areas share common problems. Results of the study, however, indicate that consistent responses to similar situations are rare.

Exposure of tree roots is unusually pronounced on most Bob Marshall campsites and persists even when ground vegetation has recovered.

Cole and Washburne suggest that differences in management philosophies of the agencies are a major source of this inconsistency. They say, "This lack of consistency is not entirely bad." Different environmental and use situations demand some flexibility in management.

Future research

"Guesswork is just not good enough for the challenge of wilderness management now and in the future," Lucas says. Additional study, in close communication and cooperation with management, is the most efficient way to develop the knowledge and techniques necessary to meet wilderness management objectives.

Is there any alternative to managing a Wilderness? "No," says Lucas, "the real question is not whether a Wilderness will be managed but rather how it will be managed, to help ensure that Wilderness will remain 'untrammeled by man.' "

Publications available

If you would like to know more about these studies, write to the Intermountain Station for the following publications:

Cole, David N. 1983. *Assessing and Monitoring Backcountry Trail Conditions*. USDA Forest Serv. Res. Pap. INT-303. 10 p.

Cole, David N. 1983. *Campsite Conditions in the Bob Marshall Wilderness, Montana*. USDA Forest Serv. Res. Pap. INT-312. 18 p.

Cole, David N. 1983. *Monitoring the Condition of Wilderness Campsites*. USDA Forest Serv. Res. Pap. INT-302. 10 p.

Cole, David N. 1982. *Wilderness Campsite Impacts: Effect of Amount of Use*. USDA Forest Serv. Res. Pap. INT-284. 34 p.

Cole, David N., and John Dalle-Molle. 1982. *Managing Campfire Impacts in the Backcountry*. USDA Forest Serv. Gen. Tech. Rep. INT-135. 16 p.

Lucas, Robert C. 1983. *Low and Variable Visitor Compliance Rates at Voluntary Trail Registers*. USDA Forest Serv. Res. Note INT-326. 5 p.

Lucas, Robert C. 1981. *Redistributing Wilderness Use Through Information Supplied to Visitors*. USDA Forest Serv. Res. Pap. INT-277. 15 p.

Washburne, Randel F., and David N. Cole. 1983. *Problems and Practices in Wilderness Management: A Survey of Managers*. USDA Forest Sev. Res. Pap. INT-304. 56 p.

Not available from the Intermountain Station, but available from libraries, are the following:

Lucas, Robert C. *Recreation Regulations—When are They Needed?* J. For. 80:148–151; 1982.

Lucas, Robert C. *The Role of Regulations in Recreation Management*. West. Wildlands. 9:6–10, 1983.

ROS: Integrating recreation into land management planning

by Matthew McKinney

Recreational use of wildlands has greatly increased in the past 20 years and is expected to continue. The type, quantity, and quality of recreational opportunities are influenced by timber harvesting, water projects, energy development, and other resource uses. In addition, different types of recreational opportunities are often demanded from the same areas. Therefore, land managers need improved techniques for: (1) assessing the demand for outdoor recreation; (2) estimating the capability of particular areas for recreational opportunities; (3) inventorying available and potential recreational resources; (4) better integrating recreation into land management planning; and (5) monitoring the impacts of resource uses on recreation, and of recreation on other resource uses.

To aid land managers with this complex task, resource specialists with the Forest Service and BLM, and researchers with the Forest Service's Rocky Mountain, Intermountain, and Pacific Northwest Stations, Colorado State University, Oregon State University, and the University of Nevada have developed a system to enable managers to put into practice a concept for inventorying, classifying, managing, and monitoring outdoor recreation resources. This concept, known as the "Recreation Opportunity Spectrum" or ROS, involves estimating the demand for recreational opportunities and then identifying appropriate settings for desired activities and experiences. The ROS, therefore, outlines three components of a recreation opportunity; activity, setting, and experience.

According to Dr. Bev Driver, a research forester with the Rocky Mountain Station's Valuation of Wildland Resource Benefits research work unit and a major collaborator on the ROS, "the basic assumption of the recreation opportunity spectrum concept is that, by providing a diverse range of recreational settings (for example roadless forests, developed marinas and interpretive trails), recreationists can participate in the types of activities (such as wilderness camping, motorboating and hiking) that produce desired results (attaining solitude, being with friends and learning about nature.)" Based on this assumption, he continues, "the ROS helps guide the generation of recreation demand and supply information."

The primitive ROS class is characterized by an unmodified natural environment where a recreator may experience isolation from the sights and sounds of man.

Operationalizing the concept

To make the ROS concept operational, six broad classes of recreational opportunity are commonly specified: primitive, semiprimitive non-motorized, semiprimitive motorized, road-natural, rural, and urban. Some planners have identified subclasses to meet local conditions and needs. Each class is defined according to the mix of activity, setting and experience opportunities available.

For example, the "primitive" ROS class offers the opportunity to experience isolation from the sights and sounds of man, to experience a high degree of risk or challenge, and to use outdoor skills. The setting is characterized by an essentially unmodified natural environment of a very large size. The density of users is very low and evidence of others is minimal. The area is managed to reflect minimal evidence of man-induced restrictions and controls. Motorized use within the area is prohibited.

In contrast, the "urban" ROS class provides recreation opportunities characterized by higher use densities and considerable modification of the area. Therefore, large groups of people are common and the sites are highly developed. Opportunities for wildland challenges and solitude are not available. The setting is characterized by a predominantly urban environment, although the background may have some natural elements. Vegetation is often exotic and manicured. Sights and sounds of man dominate the area. A considerable number of facilities are designed for the use and convenience of a large number of people. Controls are obvious and numerous. Intensified motor use is common.

Semi-primitive non-motorized areas offer a high probability of experiencing solitude, tranquility, independence, self-reliance, and closeness to nature.

In general, Driver says, "the ROS is an improved method for identifying recreation opportunities as well as for integrating recreation into the land management planning process. Field applications by the Forest Service and BLM indicate that the ROS is relatively inexpensive to apply, appeals to many land managers, and is fairly understandable by both the public and managers."

ROS is currently the basic approach used by the Forest Service and BLM to integrate recreation values into multiple-use or integrated land management planning. It is also used by other federal agencies, a few state resource agencies, and several foreign countries.

Using the ROS

The ROS is used to help guide the collection and interpretation of recreation demand and supply information. In terms of demand, a basic purpose of the ROS is to help assure that desired recreational opportunities are provided. According to Driver, "although the ROS system does not provide guidelines for making these recreation demand and needs assessments, it does provide a much improved conceptualization of the outputs (or goods and services) which are both demanded by the user and produced by recreation management, by defining outputs as specific types of recreation opportunities along a spectrum. For example, the opportunity to hike in a primitive ROS zone is a different output from the opportunity to hike in a roaded-natural ROS zone." In addition to helping specify outputs, the terminology of the ROS system helps improve articulation of recreation-related issues, concerns and opportunities, thereby contributing toward development of more explicit planning goals and decisions.

ROS also makes a major contribution to the resource inventory and classification (or supply) phase of planning. It provides a much improved means for evaluating the capability of a particular area to provide different types of recreational opportunities. Using the ROS, a clear picture of existing and potential recreational opportunities is

provided by considering access into an area, size of area, remoteness, non-recreation resource uses, type and extent of management, social interactions, and user density. In addition, map boundaries for each ROS class and information on acreage and recreation capacity available for each ROS class can be outlined.

From the supply perspective, the most important component of the recreation opportunity is the setting. It is the setting that is inventoried and managed. For greater specificity in planning, the ROS identifies three types of settings: physical, social, and managerial. Each type of setting can affect the type, quantity, and quality of recreation opportunities currently and potentially available.

For instance, the physical setting, which includes natural as well as cultural resources, influences the opportunity to view scenery, study nature, or take risks. The social setting, which depends on the number and behavior of users in an area, influences opportunities for experiencing solitude or the companionship of several people. And characteristics of the managerial setting influence, among other things, the degree of protection from harm and the sanitation services available. The managerial setting may also provide opportunities for learning through interpretive programs, and restrict or expand the freedom of users through regulations.

ROS in Land Management Planning

After using the ROS system to estimate the demand for recreational opportunities and to inventory areas in terms of their existing and potential recreation opportunities, "it is much easier to integrate recreation into the land management planning process than it is without the ROS," Driver says. The supply and demand information generated by the ROS helps managers more clearly outline management goals and objectives. The ROS also helps assure that desired recreational opportunities will be matched with the opportunities actually provided when the plan is implemented. In addition, the ROS helps guarantee that a range or spectrum of opportunities will be provided from which users can choose according to their individual values and abilities.

The rural ROS class is characterized by a high probability of interaction with other individuals.

In addition to identifying the recreation opportunities available under different management scenarios, the ROS system can also identify the impact of different resource uses on the recreation resource. For instance, the impact of mineral development or timber harvesting on a particular ROS class can be easily determined—i.e. if an access road is constructed into a primitive area, that area could no longer provide primitive-type recreational experiences. Alternatively, if an area is formally classified as primitive, this would constrain other types of recreation and non-recreation resource use. Driver says, "the ROS provides a mechanism for analyzing trade-offs of alternative recreation resource uses and other resource uses on existing and potential recreational opportunities." Therefore, he says, the ROS is useful in environmental impact analysis.

Driver also reports that "the ROS can be used to evaluate the degree to which planned recreation opportunities are actually provided." For example, a certain area might be planned to provide semi-primitive non-motorized types of recreation. However, after the plan is implemented, use may become excessive or motorized vehicles common. In such a case, there is an inconsistency between planned and actual recreation opportunities available. The ROS can easily identify and monitor such inconsistencies, as well as justify deviations from planned actions as new resource needs arise and as agency funding levels change.

Finally, the ROS can help managers better communicate and interact with recreationists. By providing recreationists with information about the setting and activities expected in an area, managers can help recreationists match their desired experiences with appropriate settings.

Urban recreational areas are characterized by a predominantly urban environment, manicured vegetation, and a considerable number of facilities.

For More Information

Below is a list of handbooks and other literature that discuss various aspects of the ROS, including basic concepts, estimating demand, inventorying resources, and management planning and evaluation.

(1) *The Opportunity Spectrum Concept and Behavioral Information in Outdoor Recreation Resource Supply Inventories: A Rationale.* B.L. Driver and Perry J. Brown, Integrated Inventories of Renewable Natural Resources: Proceedings of the Workshop, General Technical Report RM-55, Rocky Mountain Station, 1978. Also see *The Opportunity Spectrum Concept and Behavioral Information in Outdoor Recreation Resource Supply Inventories: Background and Applications.* Brown, Driver and C. McConnell in the same publication.

(2) ROS Users Guide. USDA Forest Service

(3) Roger N. Clark and George H. Stankey. *The Recreation Opportunity Spectrum: A Framework for Planning, Management, and Research.* GTR PNW-98. Dec. 1979. 32 pgs.

(4) Leon J. Buist and Thomas A. Hoots, *Recreation Opportunity Spectrum Approach to Resource Planning.* Journal of Forestry, Feb. 1982. pgs. 84–86.

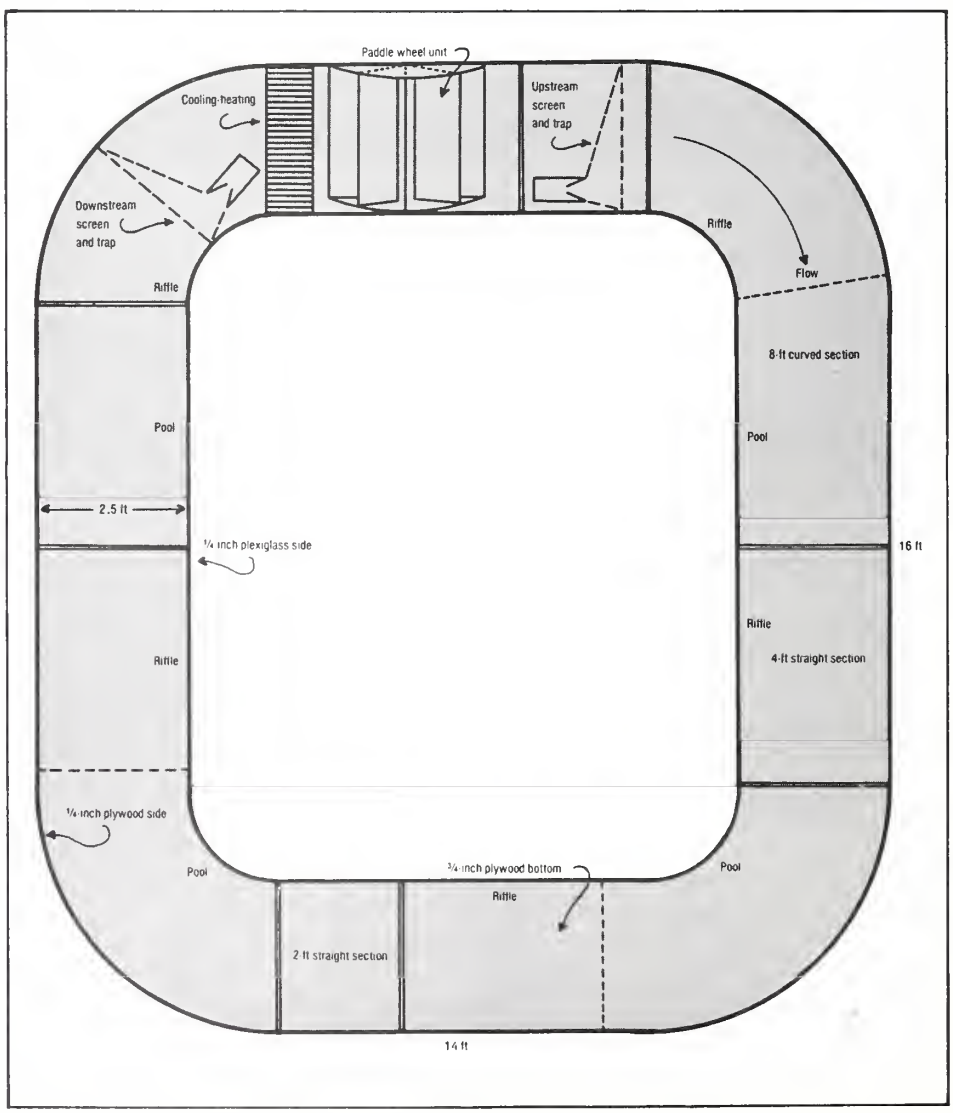
Stream aquarium constructed for research

by Samuel T. Frear
Pacific Northwest Station

A person familiar with a home aquarium, equipped with lights, filtration system, aeration apparatus, and heater, and requiring regular feeding of fish and caring for their needs, will appreciate the giant fishtank that scientist Fred H. Everest oversees.

Known as a "Recirculating Stream Aquarium," it is used for ecological studies of anadromous fish (those that migrate from sea to fresh water). The home hobbyist also would appreciate the operation's scale. The aquarium, located at the Forestry Sciences Laboratory in Corvallis, has two 2-1/2 foot wide, oval-shaped channels measuring 14 by 16 feet, and composed of two levels, one above the other. Each channel contains 1,550 gallons of water.

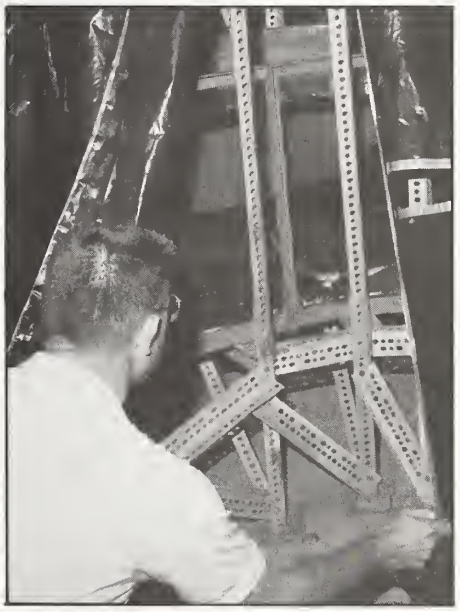
The structure differs from a home aquarium, too, in that it replicates a stream, with water flowing at varying velocities, and through riffles and pools. The system contains paddles that turn to keep water flowing, and a complex of meters, pumps, lights and



There are two channels, one above the other, and 1,550 gallons of water flow around each. submitting fish to a variety of environmental pressures.

other devices to control light, temperature, filtration, feeding, and sterilization.

Everest, a research fisheries biologist with the Pacific Northwest Station, is enthusiastic about the new aquarium. Conducting research about anadromous fish in forest streams is time consuming and long range in nature. A stream ecosystem is complex and researchers have little control over environmental variables. It often is difficult to determine the influence of an individual variable at any one time, much less many variables operating at the same time. Many research trips are required to the same place over a



The stream aquarium resembles a huge erector set in the way the two channels are supported. Fred Everest looks in on the fish.

period of many years before a researcher can feel he or she has observed all the variables operating in different combinations, and understands their significance. "It takes years of field work to unravel questions," Everest said.

Looking for answers

Some of the questions Everest and his fellow scientists are attempting to unravel, in broad terms, include the habitat requirements of fishes, the effects of human activities on habitats, rehabilitation and enhancement of fish habitat, and interactions, such as predation and competition, that affect fish.

The recirculating stream aquarium should considerably shorten the time to find answers to these concerns. Everest explained that the device permits researchers to hold environmental variables constant. Each can be adjusted to observe the effects on fish of different combinations of light intensity, length of day, water temperature, physical structure of the habitat (such as riffles, pools, and cover), water velocity, substrate composition (such as rocks and sand), food regimens, density of fish, size of fish, and combinations of species populations.

The aquarium's channels were designed to represent a small stream environment such as found in the forest, and primarily are suitable for small fish. The channels will contain salmonids less than 6 inches long, being best for salmonid fry and fingerlings. Each channel can contain 80 to 100 recently emerged salmonid frys but only 12 to 15 salmonids 5 to 6 inches long. Larger numbers of small, non-territorial fish with less rigid spatial demands can be accommodated.

The environment of the stream aquarium can be manipulated to simulate the impact of human activities on small forest streams. Logging impacts, for example, can be duplicated as if trees shading a stream were removed, raising its temperature. Or the impacts can be posed as if the flow of detritus into a stream was increased, or the water volume changed, or large debris placed within the stream.

The initial research in the aquarium is to test the interaction between nongame fish, such as Shiners and salmonids. When the temperature of a stream increases, will it negatively or positively affect one species more than another?

More to know

While it has been known, in general terms, the best habitat for fish production includes clean gravel, water flow, food, space, and protective cover, there still is much to be learned about the quantitative and qualitative limits of these requirements. How warm must a stream be before salmonids disappear, or how silted can gravel be before it no longer is suitable for spawning?

The anadromous fish research at Corvallis headed by Everest is investigating many of the "gray areas" of knowledge about the habitat requirements of salmon and trout. Subjects now being investigated include the effects of suspended sediment, of water volume on salmon biomass, of debris torrents, and of edge habitats. Researchers also are evaluating methods to enhance the habitat, and determining the role of large organic debris in a stream.

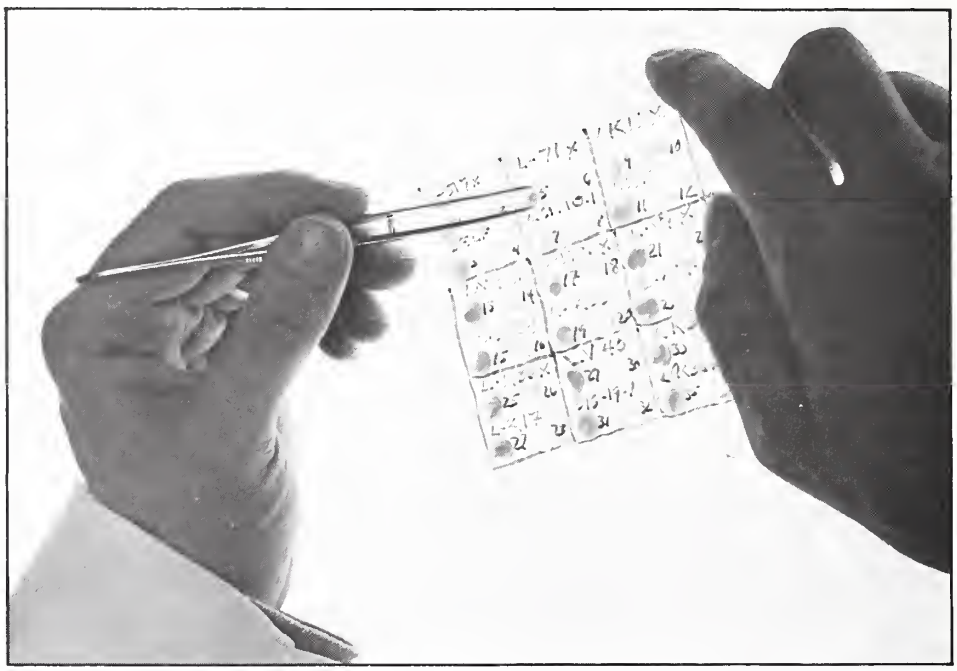
The research program at the Forest Service laboratory in Corvallis has both long-term, or basic, and short-term, or developmental, elements. The goal is to acquire as much information as possible about habitat requirements for anadromous fish, to provide a base upon which forest managers can make decisions. These decisions, to assure better use and conservation of fishery resources, will involve management direction to protect fish habitat, as well as rehabilitation and enhancement actions to provide additional habitat.

For additional information, the following publication is available from the Pacific Northwest Station:

A recirculating stream aquarium for ecological studies, Research Note PNW-403, by Gordon H. Reeves, Fred H. Everest, and Carl E. McLemore.

Isozyme Electrophoresis—The "new" forest genetics

by Richard B. Pearce



Dissected seed with gametophyte and embryo are coded and identified.

It is said that variation is the spice of life. But, for plants and animals variation is also the fundamental basis for existence.

Genetic variation has long been identified with the ability of a species to survive the vicissitudes of climate, predators, and other threats to life. The Darwinian theory on the adaptation of species to a changing environment was founded on observations of slight variations in the anatomy of kindred plants and animals. Variations on a successful theme that presumably increased the chances of survival, were viewed as random changes in the expression of what have since become known as genes. And this is why Nature endows species with multiple forms of genes—to give them the capacity to respond to environmental change.

The challenge to research geneticists over the years has been to measure variation in a meaningful way. "Classic" genetics depended on the analysis of readily apparent physical traits, called phenotypes. How these traits were inherited and the frequency by which they appeared among offspring of test matings were used to figure out the genetic make-up of individuals or populations. The wrinkled pea, the apricot-colored eye of the fruit fly, or other rare mutations could be used to specify a genetic type, or genotype. Unfortunately, these observed characteristics, although easily recorded and predictably followed for generations, have relatively little to do with survivability. They reveal even less about the overall variation among the many thousands of genes that make up an organism's genotype.

For forest geneticists, the problems of using phenotypic analysis to define genetic variation within a population, are many. Field data needs to be monitored for many generations, and the long growth time for most trees can delay analysis of the results for years. Also, it is far from certain that commonly measured characteristics—growth rate, pest resistance, weather tolerance, and so forth—accurately

reflect variation at the gene level. The quality of rapid growth, for example, is undoubtedly the sum of many factors working in concert; it reveals little of the actual genotype, or how variable the sample population actually is.

Theoretically, one way to measure variation closer to the gene level is to look—not at the physical characteristics of an organism—but the chemical, namely enzymes. Because enzymes are translated from gene templates, they reflect changes in the actual DNA sequence. Even the slightest change in the genetic code can lead to the synthesis of a structurally different enzyme. What geneticists needed was a rapid, quantitative way to identify the large number of enzyme variants within a single individual, and between individuals or whole populations.

In 1955, a Canadian named Smithies described the use of a technique called zone electrophoresis in starch gels, which he had used to analyze variations in the serum proteins of adult humans (*Biochemical Journal* 61:629–641, 1955). Over the next 10 to 15 years, adaptations of the technique, now called starch gel electrophoresis or isozyme electrophoresis, were used in medical research and by plant and forest geneticists.

First forestry isozyme laboratory

In 1970, one of the first isozyme laboratories in the world to be devoted to forestry research was established at the Pacific Southwest Station, under the leadership of M. Thompson Conkle. Since then, Conkle and his colleague, F. Thomas Ledig, project leader for the Station's research unit on forest genetics, have pioneered in the use of isozyme electrophoresis to analyze the genetic diversity of forest conifers.

Working out of laboratories in Berkeley, California, and at the Station's Institute of Forest Genetics, Placerville, California, they have fully demonstrated that the procedure is a powerful research tool that is altering the way forest scientists think about such fundamental biological processes as adaptation, evolution, development and gene expression, and conservation within forest species.

Functionally, isozymes are enzymes. The term isozyme is used to denote the minor variants among a particular class of enzyme. For example, Glucose-6-phosphate-dehydrogenase, one of the enzymes involved in the metabolism of carbohydrates, can take a variety of different forms, yet still retain its basic function. In Douglas-fir, there are six isozymes for this particular enzyme.

Principles of electrophoresis

Using the electrophoretic technique to hunt for isozymes in plant tissue is relatively straightforward and well within the technical reach of even the most modestly equipped laboratory. The biochemical principle of the technique is equally straightforward: because all proteins carry a net charge (usually negative), they will be, under the appropriate conditions, attracted to a high-voltage, positively charged anode. When an extract of the tissue to be analyzed is placed in the appropriate medium (starch gel is the standard) and subjected to a potential difference of 400 volts, the isozymes will begin to migrate towards the anode.

The isozymes spread out as they move, forming a gradient of different proteins, which later can be identified and visualized by special stains. Enzymes exhibiting the same function, but having a slightly different structure (and therefore a different net charge) will form discrete bands within the gel. Geneticists can then read the banding patterns of a particular individual, to deduce its number of isozymes, and therefore its genotype. The more isozymes, the greater the index of variability.

Genetic fingerprints of trees

Being able to genetically fingerprint individual trees or populations quickly and cheaply has opened the door to many new and interesting discoveries. Already, isozyme technology has led to rethinking of the criteria for seed selection for reforestation and breeding programs. Isozyme analysis will allow breeders to determine the source and purity of seed lots, and to check seed orchards for pollen contamination from outside sources. Isozyme technology is sure to alter scientific notions about the flow of genetic information between neighboring populations, between individuals of the same species, and even the relationship between one species and another, that is, between a pest and its host.

Electrophoresis does have its pitfalls, however. Not every alteration in a gene will result in a detectable change in the enzyme for which it codes. Therefore, the measure of genetic variation by the isozyme method is an underestimate. Another source of error is that the genes analyzed represent only those activated at the time of extraction. At any moment in the life cycle of an organism, most genes are dormant and do not produce enzymes. Electrophoresis can only detect variation among that subset of activated genes. Nevertheless as one researcher recently proclaimed, "The isozyme technique represents a quantum jump forward in the study of plant and animal genetics. It measures variation as close to the gene level as we can come."

"The isozyme technique is currently the best means for evaluating the genetic structure of forest populations,'','' says Dr. Conkle. He, Ledig, and other forest geneticists have found that, as a group, pine trees are among the most variable of any species on this planet. "Conifers have several mechanisms that promote outcrossing, and these would be expected to maintain a high level of genetic variation,'' says Dr. Ledig. Variation may prove an adaptive asset in times of adverse climatic conditions or other threats to survival. But is variation essential for survival in every case?

Relict pine populations

To test what happens when a pine species becomes geographically isolated and unable to exchange genetic material with other populations, Drs. Ledig and Conkle took advantage of a "natural experiment'' involving the Torrey pine. This species is the most restricted of all pines—inhabiting only two sites in California. A mere 7,000 trees now grow in the Torrey Pines State Reserve near San Diego and another 2,000 or less dwell on the sheltered northeast coast of Santa Rosa Island (one of the Channel Islands off the coast of California near Santa Barbara). The two populations are separated by 175 miles and unfavorable currents that virtually rule out the possibility of interbreeding between the two populations.

"We wanted to see whether the breeding system was able to maintain the high variability, which is a characteristic of pine, in the absence of migration.'' What the researchers found was rather astonishing.

Twenty-five enzyme groups from 124 trees from the San Diego reserve and another 65 from Santa Rosa Island, were subjected to electrophoretic separation. In addition to scoring the banding patterns of isozymes from growing embryos which contain both maternal and paternal genes, protein extracts were also taken from the gametophyte surrounding the embryo. Gametophyte tissue is derived from the same cell as the egg and therefore contains only half the genetic complement of the adult. It represents a vestige of the more extended "alternate generation'' of primitive plants. It also represents a unique opportunity to determine the gene content of plant tissue without the confounding effects of two sets of genes. Chromosomes in gametophyte cells are in singles instead of pairs, and that makes it possible to do some rather sophisticated genetic studies that could previously be done only with bacteria and viruses.

The study on Torrey pine, using gametophyte and embryo tissues, permitted gene typing not only of the tree from which the sample was obtained, but also of the pollen that gave rise to it's offspring. In this way, genetic data from two trees could be obtained for every seed sample analyzed. (The gene content of the pollen is deduced by subtracting the band pattern of gametophyte isozyme gels from those of whole embryo; that is, the egg from the zygote.)

Torrey pine—essentially clones

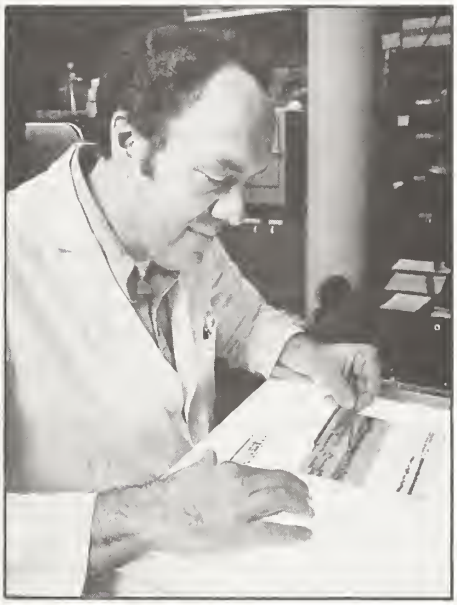
The results of the study showed that Torrey pine was uncharacteristically uniform. Indeed, the genes from every tree tested at either the San Diego or Santa Rosa sites were identical. The trees growing within each habitat were essentially clones—exact genetic copies. Variation between the two populations was also minimal, differing at only two of the 59 genes tested, or 3.4 percent (corrected for the underestimate inherent in the isozyme technique, the overall interpopulation variation was estimated to be 8.5 percent).

The remarkable uniformity of the Torrey pine is undoubtedly the result of genetic drift, the researchers conclude. When a population is reduced in size and limited in its interaction with other populations, genetic variation is slowly eroded. Australian researchers using data obtained from isozyme studies have estimated that there is a population size below which genetic variation disappears. For example, they estimate that a population of 70 trees will lose half of its variant genes after 100 generations. And, in such a short time there is little opportunity for random mutation to give rise to new ones.

In a relatively constant environment, an inbreeding population may have no real need to retain alternative forms of genes. For the Torrey pine, Drs. Conkle and Ledig reason that the arid conditions of the Xerothermic period some 3,000 to 8,000 years ago may have pushed the tree into near extinction. The researchers estimate that fewer than 50 trees may have populated the San Diego site at that time. With the return of a more favorable climate, the genetically impoverished Torrey pine steadily expanded to its present size. But, with no chance for interbreeding, the genotype for Torrey pine had no opportunity to acquire new genes.

As for the population of trees on Santa Rosa Island, the researchers surmise that they were probably started by a founder tree from some other orphan perhaps of the most recent Pleistocene glaciation, probably a group of Torrey pine on the central California coast that has long-since vanished. By chance, founders suffer a loss of gene diversity during colonization when population size is small.

Amazingly, Torrey pine has managed to survive for more than 50 generations with virtually no genes in reserve. Inbreeding may have seriously compromised its ability to endure future



Forest Geneticist M. Thompson Conkle, examines completed starch gel slice. Individual bands represent different enzymes.

years, however. Through breeding programs guided by information obtained from isozyme electrophoresis, some day it may be possible to instill genetic variation of a desired type into Torrey pine, or any other conifer, to ensure its survival. Only through basic genetic research of the kind being conducted at the Institute of Forest Genetics, can the value and usefulness of such intervention be predicted with any certainty.

"What we learn about the natural survival of forest trees among surviving natural populations, has unquestionable relevance to conservation strategies adopted to protect and reestablish national timber reserves," says Dr. Conkle. Commercial enterprises in some areas have reduced the original populations of forests to isolated relicts.

Currently, Drs. Ledig and Conkle have turned their attention to other conifer species with small geographic distributions that are also in danger of extinction. Preliminary results show that Monterey cypress has retained much genetic variation, whereas bristlecone fir, like Torrey pine is genetically impoverished.

"We expect to be relying more and more on isozyme analyses to tell us about the efficacy of current conservation programs," adds Ledig. "One distinct advantage the technique has over and above field studies, is that the laboratory need never be idle, waiting for seasonal measurements to come in."

Ledig is also using electrophoresis in studies to determine the influence of heterozygosity—genetic diversity—on growth rate of forest trees. Working with pitch pine as a model conifer, he has found that growth rate is directly related to genetic diversity. The more genetic variability carried by the tree, the greater its annual growth. The growth rate is cumulative—with increasing age, trees with high genetic variability become even larger in diameter than those with low variability.

It is known that inbreeding reduces genetic variability within family lines, and cross-breeding promotes variability. Continued inbreeding can lead to inbreeding depression–the reduction in vigor that is often attributed to deleterious recessive genes. Conversely, the multiple forms of genes in trees possessing genetic diversity could enable the trees to cope with climatic variability, thus, producing greater annual growth.

Tree-improvement programs

Whatever the reason, if the genes under study do contribute to increased growth, the finding could revolutionize tree-improvement programs, because it indicates desirable trees could be selected for their genes, rather than on the basis of growth alone, which requires long-term, expensive field trials.

Isozyme analyses have also been used to measure genetic variation in insect pests and their host trees. Differences in the isozyme content of two populations of mountain pine beetle, for example, have been used to study why in one area the insect attacks a lodgepole pine, while its cousins in a nearby stand prefer white pine. "Gene flow" for a particular insect can be followed as insect populations relocate. Someday, gene monitoring of pests may be used to predict areas of future outbreaks.

The isozyme technique can also yield basic information about how genes are arranged on the chromosomes and which chromosomes are activated at various stages of development. By running electrophoresis on several seeds from a single tree, it is possible to observe how genes are doled out when parental chromosomes segregate into the gametes—eggs and pollen. Data from such studies can be used to construct gene maps. It was out of such experiments as these in bacteria and viruses that research led to modern gene transfer techniques.

Dr. Conkle's studies of various conifer species have revealed a surprising number of linkages. In spite of the low probability of finding more than 10 genes on a single chromosome (only one in 10,000,000), Dr. Conkle has been able to find many such instances among pine. Such linkage must have a functional significance, says Conkle, who theorizes that "specific segments of a chromosome may be activated at a given time during development."

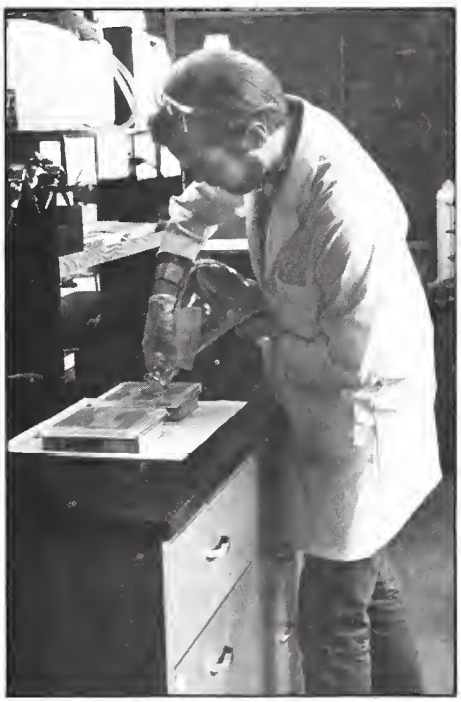
Most recently, Dr. Conkle has begun a study to locate a gene marker for resistance to blister rust in sugar pine. The implications of this kind of work have yet to be fully realized, but will surely lead to new discoveries about how genes are packaged on chromosomes, when they become active, and how they may be directly related to the survival of the species.

Electrophoresis is economical

Almost any group can establish and operate an isozyme laboratory. No costly centrifuges, scintillation counters, or incubation chambers are required. The only materials needed for isozyme study are the special stains, buffers, refrigeration and other equipment for electrophoresis—plus a healthy respect for high voltage.

The cost of running an electrophoresis lab is nominal compared to the cost of field studies. Between 80 and 90 individual plant genotypes for 40 to 60 genes can be determined in a single day for less than $100.

We've called isozyme electrophoresis the "new" forest genetics. And it is just that. In terms of genetic application, the technique itself is relatively new. The real breakthrough for genetics came in 1966, and that was on work with the fruitfly, *Drosphila pseudoobscura* (see Hubby and Lewontin, *Genetics* 54: 577–594. 1966). Plant and forest geneticists have built on that breakthrough.



PSW Technician Paul D. Hodgskiss, prepares molds of starch gel solution.

The new forest genetics will come when information obtained through isozyme electrophoresis is used to alter genes of forest trees to improve growth and form, to protect trees from insects and disease, and to add diversity to the gene structure of relict tree species, such as Torrey pine.

For technical information on laboratory procedures, write PSW Station for *Starch Gel Electrophoresis of Conifer Seeds: A Laboratory Manual*, General Technical Report PSW-64. For more general information, write for *Proceedings of the Symposium on Isozymes of North American Forest Trees and Forest Insects*, General Technical Report PSW-48.

Glossary

Isozyme: a variant form of an enzyme produced by a gene and detectable by electrophoresis as a band of more or less mobility than the more common form of the enzyme.

Allozyme: an enzyme produced by a gene at a single site, or locus, on a chromosome (there may be several genes coding for a single enzyme; the allozyme refers to a particular gene at a particular locus).

Phenotype: the outward appearance of an organism reflecting gene structure and environmental influences.

Genotype: the actual gene make-up of an organism, as revealed by isozyme analysis or classical studies of inheritance patterns for certain phenotypes.

New publications

Toward blister rust resistant western white pine

A lonely box of cuttings protruding from an 8th floor window in Spokane, Washington; protecting cones from insects in cotton flour sacks—humble beginnings of the Forest Service program to attain blister rust resistance in western white pine.

Twenty-five years of research and development work (1950–75) undertaken by Forest Service scientists and cooperators has led to experimental, soon practical, production of western white pines bred for blister rust resistance. The lonely cuttings, nurtured in 1949 by Forest Pathologist Richard T. Bingham, were the start of the program that moved through two generations of selection for resistance, culminating with the establishment of seed orchards in 1971–74. By about 1985, the 40 acres of seed orchards should be starting to mass produce second-generation seed for resistant planting stock sufficient to annually reforest 10,000 to 20,000 acres of prime white pine lands in the Inland Empire.

Bingham, Intermountain Station retiree, headed the blister rust resistant western white pine R&D program at the Station's Forestry Sciences Laboratory in Moscow, Idaho, for 25 years. Since retiring, as a Forest Service volunteer, he has recorded the methods, results, and conclusions for the first-phase program in a publication issued by the Intermountain Station.

Blister Rust Resistant Western White Pine for the Inland Empire: The Story of the First 25 Years of the Research and Development Program, General Technical Report INT-146, presents a consolidated record of information already available or produced by this and other blister rust resistance R&D programs.

Write to the Intermountain Station for a copy.

Managing western white pine seed orchards

Managers of western white pine seed orchards will find helpful information in a recent report issued by the Intermountain Station. *Recommendations for Selection and Management of Seed Orchards of Western White Pine*, Research Note INT-325, by R. J. Hoff and D. O. Coffen, is true to its title. In the report, the authors provide specific suggestions on how to locate and manage the seed orchards. They discuss spacing, fertilizing, pruning, cone harvest, and other related concerns.

Ray J. Hoff is project leader, and Dale Coffen a forestry technician, with the Intermountain Station's Genetics and Pest Resistance Research Work Unit located at the Forestry Sciences Laboratory, Moscow, Idaho.

Recommendations in the report are based primarily on data that Hoff and Coffen have collected and on experiences they have had managing the Moscow, Idaho Arboretum and the Sandpoint, Idaho, Seed Orchard.

Copies of the report are available from the Intermountain Station.

An appraisal of stream habitat evaluation methods

Success or failure of fishery habitat studies depends on the comprehensiveness and accuracy of the methods used to obtain information upon which final interpretations are based. Planners and decisionmakers using these interpretations assume that they are derived from measurements accurately describing stream habitat conditions. Problems can arise, however, if the methodology is not suitable for the environmental situation and if the accuracy of interpretations is unknown. Poor resource management decisions can result.

Within the last decade, measurements of stream habitat conditions, such as velocity, depth, and cover, have been incorporated into computer models to indicate fish populations and to assist in evaluating impacts from land management activities. The success of these models depends on whether the model fits the situation, whether the correct combination of habitat descriptors is selected, and how precisely and accurately those descriptors are measured.

In an Intermountain Station publication, researchers have analyzed some of the attributes used in computer models or in methods to determine stream habitat and biotic conditions. The report, *Methods for Evaluating Stream, Riparian, and Biotic Conditions*, General Technical Report INT-138, presents standard techniques in use, and discusses the precision and accuracy that can be expected for each measurement. The information is directed mainly toward ways of measuring the effects of land use practices, such as logging, road construction, livestock grazing, and mining.

Authors are William S. Platts, research fishery biologist, and Walter F. Megahan, principal research hydrologist, both located at the Station's Forestry Sciences Laboratory, Boise, Idaho; and G. Wayne Minshall, professor of zoology at Idaho State University, Pocatello.

Copies are available from the Intermountain Station.

Departure from "even flow" timber harvest investigated

The economies of four timber-dependent counties in Oregon and Montana have been analyzed to determine how they might be affected if timber flow from nearby National Forests changed.

A report published by the Pacific Northwest Station, investigated the economic trends during the 1970's of Flathead and Missoula counties in Montana, and Linn-Benton and Douglas counties in Oregon. The authors are Con H. Schallau, research economist at the Station's Forestry Sciences Laboratory in Corvallis, and Paul E. Polzin, professor at the University of Montana.

The Forest Service currently follows an "even-flow" harvesting policy in which the same quantity of timber is planned for harvest each year. The agency can depart from even-flow when this policy would hurt timber-dependent areas. The study provides guidelines to assess whether departures from even-flow should be considered.

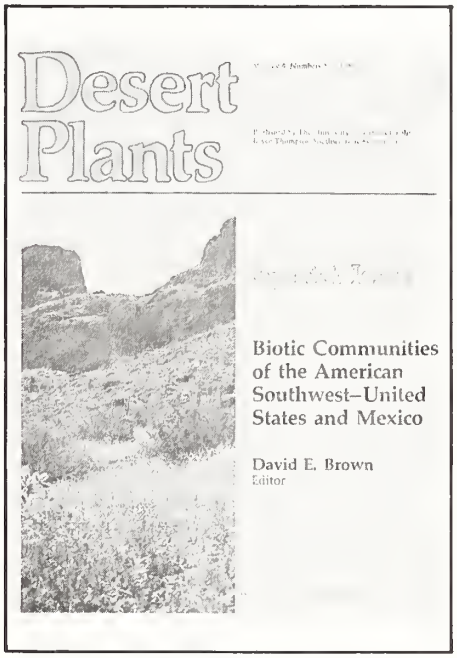
Schallau and Polzin found all four areas heavily dependent on the timber industry, but identified a stronger need to consider departure in Douglas County than for the others. Furthermore, this area may experience a significant shortage of timber in the near future. Although the Douglas County economy shows signs of diversifying, the growth of new industries may not compensate for declining timber supplies and timber-based employment.

Schallau and Polzin found that the Missoula Montana area is more dependent on timber than in 1970, while Flathead County is less dependent. Timber harvests from privately-owned lands in western Montana increased markedly during the 1970's, while public supplies declined.

The researchers said that if the harvest from private lands cannot be maintained, the Missoula and Flathead areas may compete for a diminishing supply of timber. The two authors believe that the Forest Service must analyze the economic future of the two counties jointly before resolving the departure issue. Separate analyses could result in a remedy that benefits one area at the expense of the other, or, even worse, benefits neither one.

Copies of *Considering Departures from Current Timber Harvesting Policies: Case Studies of Four Communities in the Pacific Northwest*, Research Paper PNW-306, by Con H. Schallau and Paul E. Polzin, is available from the Pacific Northwest Station.

Biotic communities of the Southwest



The Rocky Mountain Station, in cooperation with the Arizona Game and Fish Department and the University of Arizona's Boyce Thompson Arboretum, has published a book that describes the biotic communities of the Southwest. The book is a special issue of *Desert Plants* and describes the biotic communities outlined on an accompanying map. Information on vegetation is presented in a hierarchical system, from general biogeographic characteristics to specifics such as composition, structure, and density. This information is useful at different levels of planning and management—national, regional, or local.

The use of the biotic community map and book will help land managers estimate the biological capabilities and potential uses of the Southwest's renewable resources. The plant and animal data in this book also provide information to develop local and regional wildlife data bases. These data bases can be used in preparing environmental impact statements, evaluating land management practices and developing habitat improvement projects.

A limited number of these publications and the accompanying maps are available by contacting the Rocky Mountain Station. Additional copies can be purchased from the Boyce Thompson Southwestern Arboretum, P.O. Box AB, Superior, Arizona, 85273.

Snag habitat management symposium proceedings out

At least 85 species of North American birds excavate nesting holes, use cavities resulting from decay, or use holes created by other species in dead or deteriorating trees. Such trees, commonly called snags, are also important to various mammals, reptiles, amphibians and invertebrates. Unfortunately, snags are often considered undesirable because they are not aesthetically attractive, may harbor forest insect pests and are labeled as fire and safety hazards. Dead trees are also popular sources of fuelwood. Resource specialists have long recognized the value of snags to wildlife, but they still need additional information to resolve conflicts between snag management and other resource objectives.

In response to this need, Northern Arizona University, the Arizona Game and Fish Department, the Wildlife Society, and the USDA Forest Service sponsored a symposium on snag habitat management at Northern Arizona University, June 7-9, 1983. The proceedings, including 41 papers, focus on the need to integrate management of snags with other resource uses and demands. The different sessions concentrated on management, habitat and species requirements, and monitoring and modeling. This information illustrates the state-of-the art in concepts and practices, and should help managers more easily integrate snag management into multiple-use land management planning.

To get your copy of *Snag Habitat Management: Proceedings of the Symposium*, contact the Rocky Mountain Station and request General Technical Report RM-99.

Fire—A natural component

Wildfire plays a major role in forest succession throughout the Northern Rocky Mountains, including those forests east of the Continental Divide in Montana. Lodgepole pine, for example, owes its present widespread occurrence to past fire. Without fire, Douglas-fir would occupy areas where ponderosa pine now occurs but is not climax.

The Intermountain Station has published a report summarizing fire ecology and management information that applies to forest habitat types east of the Continental Divide in Montana. Authors are William C. Fischer, research forester at the Station's Northern Forest Fire Laboratory, Missoula, Montana, and Bruce D. Clayton, Mariposa, California, employed by the Northern Region to work on the cooperative Region/Station study.

In the report, Fischer and Dr. Clayton group forest habitat types of Montana into 12 Fire Groups based on the response to fire of nine major tree species and the roles of these species during successional stages. For each Fire Group, the researchers present (1) the relationship of the tree species to fire, (2) fire effects on undergrowth, (3) forest fuels, (4) the natural role of fire, (5) fire and forest succession, and (6) fire management considerations. In the latter group, the authors suggest how the information can be used to develop plans that support land and resource management objectives.

Copies of *Fire Ecology of Montana Forest Habitat Types East of the Continental Divide*, General Technical Report INT-141, are available from the Intermountain Station.

Coast ranges clearcuts are attractive to birds

Scientists are studying birds in clearcuts in the Oregon Coast Ranges. This is one of the most heavily logged regions in North America, and data about the effects of logging on wildlife is needed for forest planning.

During the early years following harvest of timber, the researchers, financed by the Pacific Northwest Station, found that avian communities such as sparrows, towhees, and warblers prefer the shrub-dominated habitat as found in clearcuts.

Two scientists from Oregon State University studied the bird populations in 13 clearcuts on land in the Oregon Coast Ranges managed by the Suislaw National Forest. Graduate Student Michael L. Morrison and E. Charles Meslow, leader of the Oregon Cooperative Wildlife Research Unit at OSU, found that 15 to 19 species nested on each of the clearcuts, ranging from 322 to 588 birds per 100 acres. The units were sampled during 1979, 1980, and 1981.

The common or abundant birds nesting in the clearcuts all shared the same characteristic of nesting and foraging on or near the ground. The most common species are white-crowned and song sparrows; rufous-sided towhee; rufous hummingbird; orange-crowned, MacGillivary's, and Wilson's warblers; willow flycatcher; and Swainson's thrush.

The researchers believe that forest managers can take action to increase the number and kinds of birds nesting in harvested areas. To attract other species, most of which were seen in and around the 13 clearcuts, the authors recommend maintaining patches of deciduous trees to provide habitat for birds requiring vertical structure for nesting; retaining snags in clearcuts for use by cavity nesters such as hairy woodpeckers, western bluebirds, and chestnut-backed chickadees; and leaving large, downed logs in the areas for foraging by birds such as pileated woodpeckers and common flickers.

Copies of *Avifauna Associated with Early Growth Vegetation on Clearcuts in the Oregon Coast Ranges*, Research Paper PNW-305, are available from the Pacific Northwest Station.

LLAFFS—A system to locate lightning and forecast fires

Fire researchers at the Intermountain Station's Northern Forest Fire Laboratory, Missoula, Montana, have developed a new system to calculate the probability of lightning fires. The system estimates the probability that lightning will ignite fuels on the ground, and can transmit results to land managers. Probability is estimated using variables that are measures of the fuel state and type, rain, and lightning.

The method, developed by Don J. Latham, meteorologist at the Fire Laboratory, is presented in *LLAFFS, A Lightning-Locating and Fire-Forecasting System*, Research Paper INT-315, published by the Intermountain Station.

Latham and others have developed a method for storing and transmitting the lightning fire probability data using a simple printing terminal. The key to the method is that the area occupied by a character on a printed page of text, called a pixel, can be made to correspond to a geographical area on a map. Transparent map overlays then "store" permanent information such as lookouts, roads, geographic features, areas of responsibility, or other desired data.

Copies of the report are available from the Intermountain Station.

Information compiled about western redcedar

The privately-owned timberlands in western Oregon are considered by many analysts to be of key importance if the state is to continue its output of wood products. A report by the Pacific Northwest Station analyzes the statistics about the 46 percent (or 6,222,000 acres) of western Oregon's timberlands that are privately owned.

The data for private timberlands is normally categorized in the two ownership classes of forest industry and non-industrial. For this report, the second category is broken down into farmer, individual, and corporate owners. This breakdown is important for estimating timber resources available for the lumber market because, in general, the owners of small individual holdings are mostly interested in recreational and esthetic values, while owners of larger corporate holdings are more concerned with economic returns.

In western Oregon, 61 percent of all private timberland is owned by the forest industry, 17 percent by farmers, 16 percent by individuals, and 6 percent by corporations. Author Donald R. Gedney provides 44 tables showing area, volume of growing stock, net annual growth, and other statistics about this private timberland.

Copies of *The Privately-Owned Timber Resources of Western Oregon*, Resource Bulletin PNW-99, are available from the PNW Station.

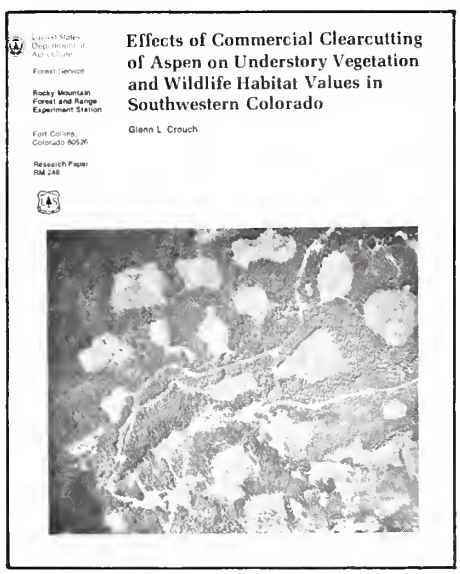
Impacts of clearcutting aspen

Aspen is the most abundant deciduous tree in the central Rocky Mountains. It provides habitat for many birds and mammals, shelter for livestock and contributes to the scenic beauty of the Rocky Mountains. Aspen is also becoming valuable in some areas for its potential wood products.

As the economic value of aspen increases, forest managers must learn how to harvest the timber while maximizing benefits to wildlife, range and all other resources. However, the most economical method to renew aspen, and thereby ensure future harvestable stands, is clearcutting, which affects understory vegetation and wildlife habitat.

To better understand the impact of clearcutting aspen on understory vegetation and wildlife habitat, Glenn Crouch, a research wildlife biologist with the Rocky Mountain Station, studied commercial clearcuts in southwestern Colorado. He observed that "five years after clearcutting, the understory characteristics changed very little, except for a large increase in aspen sprouts, which was expected." Shrubs, grasses and forbs were initially depressed, but recovered by the second year after logging. This resulted in higher use of clearcut than uncut areas by cattle for grazing. However, cavity nesters and other species requiring mature aspen forests were adversely affected by removal of the overstory. "From a wildlife habitat viewpoint, more benefits might have accrued if the timber cutting extended over 10 or more years," says Crouch.

For a detailed account of this study, a copy of *Effects of Commercial Clearcutting of Aspen on Understory Vegetation and Wildlife Habitat in Southwestern Colorado*, Research Paper RM-246, is available from the Rocky Mountain Station.



Effects of chemicals on fish habitat

The effects of forest chemicals on anadromous fish habitat in the West are summarized in a recent publication of the Pacific Northwest Station.

The report is in a series of publications examining the influence of forest and rangeland management on these habitats. *Forest Chemicals* was written by Logan A. Norris of PNW's Forestry Sciences Laboratory in Corvallis, Harold W. Lorz of the Oregon Department of Fish and Wildlife, and Stanley V. Gregory of the Fish and Wildlife Service, U.S. Department of Interior.

The three authors review current published and unpublished reports and data about seven herbicides, five insecticides, and urea fertilizers and the ammonium based fire retardants. Behavior in the environment and toxicity are described for each chemical. In addition, the report discusses use of chemicals, hazard assessment (or toxicological risk), direct and indirect effects of forest chemicals, and research needs.

Herbicides covered are 2,4-D, picloram, atrazine, MSMA, fosamine ammonium, glyphosate, and dinoseb. The insecticides are malathion, carbaryl, azinphos-methyl, carbofuran, and acephate.

Copies of *Forest Chemicals*, General Technical Report PNW-149, are available from the Pacific Northwest Station.

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Please send the following Pacific Northwest Station publications:

- ☐ *Dynamics of Understory Biomass in Sitka Spruce-Western Hemlock Forests of Southeast Alaska*, a reprint.
- ☐ *Avifauna Associated with Early Growth Vegetation on Clearcuts in the Oregon Coast Ranges*, Research Paper PNW-305.
- ☐ *Considering Departures from Current Timber Harvesting Policies: Case Studies of Four Communities in the Pacific Northwest*, Research Paper PNW-306.
- ☐ *Forest Chemicals*, General Technical Report PNW-149.
- ☐ *The Privately-Owned Timber Resources of Western Oregon*, Resource Bulletin PNW-99.
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